

R E M A R K S

I. Introduction

In response to the pending Office Action, Applicants respectfully submit that all pending claims are patentable over the cited prior art, for the reasons set forth below.

II. The Rejection Of Claims 1, 4 And 5 Under 35 U.S.C. § 103

Claims 1, 4 and 5 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Eylem et al. (USP No. 7,049,030) in view of Noriyuki et al. (JP 2000-082503). Applicants respectfully traverse this rejection for at least the following reasons.

Independent claim 1 recites an alkaline battery comprising: a negative electrode including a negative electrode mixture that contains a zinc alloy as an active material, the zinc alloy containing at least aluminum, an alkaline electrolyte, and a positive electrode. The alkaline electrolyte comprises an aqueous KOH solution and LiOH and aluminum hydroxide that are dissolved in the aqueous KOH solution. A portion of the alkaline electrolyte is contained in the negative electrode mixture. The amounts of the LiOH and the aluminum compound contained in the portion of the alkaline electrolyte in the negative electrode mixture are 0.1 to 2 wt % and 0.001 to 0.2 wt % of the negative electrode mixture, respectively.

One feature of independent claim 1 is that the negative electrode contains an alkaline electrolyte having LiOH and aluminum hydroxide contained in the portion of the alkaline electrolyte in the negative electrode mixture in an amount of 0.1 to 2 wt % and 0.001 to 0.2 wt % of the negative electrode mixture, respectively. As a result of this feature, an alkaline battery having excellent discharge capacity is obtained.

In a previous response, Applicants demonstrated that the claimed range of aluminum hydroxide, being 0.001 to 0.2 wt %, provides unexpectedly superior results to values outside the claimed range. Tables 2 and 3 of the specification were used to support this finding of unexpected superior results. However, in the Response to Arguments section of the Office Action, the Examiner maintains the position that without a showing of criticality for the claimed range over the prior art, the limitation is considered obvious in view of the teachings of Eylem. The Examiner asserts that “[t]ables 2 and 3 are not representative of the teachings of Eylem and/or Noriyuki (see, Table 1 of the present specification).” Applicants respectfully disagree.

Applicants would point out to the Examiner that a showing of unexpected results is designed to overcome an obviousness rejection by showing that a smaller range within the range disclosed in the prior art shows unexpected results. MPEP § 2144.05 states that Applicants can rebut a *prima facie* case of obviousness based on overlapping ranges by showing the criticality of the claimed range. “The law is replete with cases in which the difference between the claimed invention and the prior art is some range or other variable within the claims. . . . In such a situation, the applicant must show that the particular range is critical, generally by showing that the claimed range achieves unexpected results relative to the prior art range.” *In re Woodruff*, 919 F.2d 1575, 16 USPQ2d 1934 (Fed. Cir. 1990). Tables 2 and 3 show data which prove that batteries containing the claimed range of aluminum hydroxide show unexpected and superior results to batteries outside the claimed range. Claim 1 was rejected over Eylem on the basis that Eylem teaches “less than or equal to 2 wt% and less than 1 wt% of aluminum in the claimed electrolytic solution.” This encompasses the range of aluminum hydroxide of claim 1, that being aluminum hydroxide in a concentration of 0.001 to 0.2 wt%. Tables 2 and 3 have a combined 42

different batteries with less than 2% of aluminum in an electrolytic solution. As such, Tables 2 and 3 are commensurate in scope with the cited prior art.

The Examiner also asserts that “[t]ables 2 and 3 are not commensurate in scope with the claimed invention. For example, Table 2, shows values for various zinc alloys. The claimed invention does not recite any specific zinc alloy composition.”

This argument is non-sensical. Claim 1 recites a zinc alloy containing at least aluminum. Tables 2 and 3, the compositions of which are recited in Table 1, show zinc alloys, each containing aluminum. Thus, Tables 1-3 are commensurate in scope with the claims. The fact that no specific zinc alloy is claimed is completely irrelevant. In the chemical arts, it is common practice to claim a class of compounds each united by common characteristics. Some other alloys in Table 1 have aluminum and some other metal. Thus, claim 1 recites a class of compound in which every one of the zinc alloys contains “at least aluminum”.

For the Examiner’s benefit, Applicants include Attachment 1, showing Tables 1-3 of the specification. Applicants direct the Examiner to materials A2 to A6 of Table 2. As can be seen, batteries containing materials A5 and A6 show superior characteristics to batteries containing materials A2-A4. There are two conclusions one could make concerning this data: (a) that the amount of aluminum hydroxide in the electrolytic solution being in the claimed range provides superior characteristics to the batteries, or (b) that the presence of Sn and Pb is beneficial, whereas the presence of Bi, In and Ca is not.

Materials A13 and A14 contain Sn and Pb, respectively. Yet, the P% and discharge values of batteries containing materials A13 and A14 are worse than battery A10, which contains Bi, In and Ca, which contradicts conclusion (b) above. However, A10 contains 0.15 wt% of

aluminum hydroxide, which is in the claimed range, whereas A13 and A14 contain 0.25 and 0.3 wt% aluminum hydroxide, which is outside the claimed range. Thus, this comparison supports conclusion (a) above.

In another comparison, materials A11 and A12 have Sn and Pb added which according to the example of A2-A6, should have better values than A7, which contains Bi and In. However, the values show slight advantages for A7 as compared to A11 and A12. Thus, the results comparing A7 to A11 and A12 also do not coincide with the results comparing A5 and A6 to A2-A4, if one assumes conclusion (b). However, all three results support conclusion (a), because the batteries outside the claimed range of aluminum hydroxide (A2-A4 and A13-A14) show far worse characteristics than those in the claimed range (A5-A7 and A11-A12). Accordingly, the conclusion one must draw from these comparisons is that the claimed range of aluminum hydroxide is critical to the performance of the battery.

This is made clear in Table 2 in which all materials outside the claimed range of aluminum hydroxide (i.e., A1-A4, A13-A14, B1-4, B13-B14, C1-C4 and C13-C14) have far inferior characteristics compared to batteries with aluminum hydroxide within the claimed range (i.e., A5-A12, B5-B12, and C5-C12), regardless of what additional metals are added to the zinc material. Accordingly, the addition of Sn, Pb, Bi, In and Ca do not affect the characteristics of the battery. Paragraph [0010] of the specification discusses the use of added elements Bi, In, Ca, Sn and Pb to increase hydrogen overvoltages of zinc for improving corrosion resistance of zinc and suppressing gas production. These elements are not used to improve the characteristics demonstrated in Table 2. Furthermore, the batteries in Table 3, all of which have the claimed range of aluminum hydroxide, show superior results to those batteries outside the claimed range.

Accordingly, Tables 2 and 3 do exhibit examples commensurate in scope with claim 1 and the Tables 2 and 3 demonstrate the criticality of the claimed ranges. As such, Applicants submit the specification does support Applicants' claim regarding unexpected results, and therefore, Eylem and Noriyuki, alone or in combination, do not render amended independent claim 1 obvious. Accordingly, Applicants submit that claim 1 is allowable and patentable over the cited prior art.

III. All Dependent Claims Are Allowable Because The Independent Claim From Which They Depend Is Allowable

Under Federal Circuit guidelines, a dependent claim is nonobvious if the independent claim upon which it depends is allowable because all the limitations of the independent claim are contained in the dependent claims, *Hartness International Inc. v. Simplimatic Engineering Co.*, 819 F.2d at 1100, 1108 (Fed. Cir. 1987). Accordingly, as amended claim 1 is patentable for the reasons set forth above, it is respectfully submitted that all pending dependent claims are also in condition for allowance.

IV. Conclusion

Having fully responded to all matters raised in the Office Action, Applicants submit that all claims are in condition for allowance, an indication of which is respectfully solicited.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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diffusion paper 15 permits uniform diffusion of air that is introduced from an air vent 17 in the bottom of the case 11 into the case.

[0030] A sealing plate 18 serving as the negative electrode terminal contains a negative electrode mixture 19 comprising a zinc alloy powder and an electrolyte, and a ring-shaped insulating gasket 20 is fitted to the periphery thereof. The sealing plate is combined with the case 11, and the edge of the case 11 is crimped onto the sealing plate with the insulating gasket 20 therebetween, to seal the power generating element. Seal paper 21 affixed to the outer bottom face of the case closes the air vent 17 when the battery is not used, thereby blocking the entrance of air and preventing battery deterioration due to self-discharge. The air electrode 13 is produced by bonding a catalyst composition mainly composed of a metal oxide such as manganese dioxide, graphite, activated carbon, and a fluorocarbon binder to a current collector net under pressure.

EXAMPLES

[0031] Examples of the present invention are hereinafter described.

Example 1

[0032] AA-type alkaline dry batteries and coin-type PR230 air batteries as described in Embodiments 1 and 2 were fabricated and evaluated for their characteristics.

[0033] As shown in Table 1, the zinc alloys of these negative electrodes are alloys containing Al or containing Al and one or more elements selected from the group consisting of Bi, In, Ca, Sn, and Pb, and there are three forms: powder, porous sintered material, and plate. Also, as shown in Table 2, the electrolytes used were 34 wt % aqueous KOH solutions to which LiOH and Al(OH)₃ were added in various ratios. These electrolytes contain 1.5 wt % of ZnO dissolved therein. The contents of Al and other elements in the negative electrode zinc alloy are as follows.

[0034] Al; 5 to 70 ppm, Bi; 50 to 400 ppm, In; 100 to 800 ppm, Ca; 2 to 50 ppm, Sn; 10 to 400 ppm, Pb; 2 to 50 ppm.

TABLE 1

Material	Element added to zinc	Zinc form
A1	Al	Powder
A2	Al and Bi	Powder
A3	Al and In	Powder
A4	Al and Ca	Powder
A5	Al and Sn	Powder
A6	Al and Pb	Powder
A7	Al, Bi and In	Powder
A8	Al, In and Ca	Powder
A9	Al, Sn and Pb	Powder
A10	Al, Bi, In and Ca	Powder
A11	Al, Bi, In and Sn	Powder
A12	Al, Bi, In and Pb	Powder
A13	Al, Bi, In, Ca and Sn	Powder
A14	Al, Bi, In, Ca, Sn and Pb	Powder
B1	Al	Porous sintered material
B2	Al and Bi	Porous sintered material
B3	Al and In	Porous sintered material
B4	Al and Ca	Porous sintered material
B5	Al and Sn	Porous sintered material
B6	Al and Pb	Porous sintered material
B7	Al, Bi and In	Porous sintered material
B8	Al, In and Ca	Porous sintered material
B9	Al, Sn and Pb	Porous sintered material
B10	Al, Bi, In and Ca	Porous sintered material

TABLE 1-continued

Material	Element added to zinc	Zinc form
B11	Al, Bi, In and Sn	Porous sintered material
B12	Al, Bi, In and Pb	Porous sintered material
B13	Al, Bi, In, Ca and Sn	Porous sintered material
B14	Al, Bi, In, Ca, Sn and Pb	Porous sintered material
C1	Al	Plate
C2	Al and Bi	Plate
C3	Al and In	Plate
C4	Al and Ca	Plate
C5	Al and Sn	Plate
C6	Al and Pb	Plate
C7	Al, Bi and In	Plate
C8	Al, In and Ca	Plate
C9	Al, Sn and Pb	Plate
C10	Al, Bi, In and Ca	Plate
C11	Al, Bi, In and Sn	Plate
C12	Al, Bi, In and Pb	Plate
C13	Al, Bi, In, Ca and Sn	Plate
C14	Al, Bi, In, Ca, Sn and Pb	Plate

[0035] The respective batteries were placed in a constant temperature oven at 20° C. and a relative humidity of 60%. The air batteries were discharged at a current of 160 mA, and the alkaline dry batteries were discharged at a current of 1 A, whereby the discharge capacity C1 (mAh) was obtained. Also, the theoretical capacity C2 (mAh) was calculated from the weight of Zn contained in the negative electrode of each battery. The proportion P (%) of the discharge capacity C1 to the theoretical capacity C2 was calculated from the following formula (1), to evaluate the high-rate discharge characteristics of each battery. The higher P value a battery has, the better high-rate discharge characteristics the battery has. Also, to obtain battery capacity, the air batteries were discharged at a current of 3 mA and the alkaline dry batteries were discharged at a current of 50 mA. Table 2 shows the results. In the following Table 2 and Table 3, the wt % of LiOH and Al(OH)₃ represents the ratio relative to the negative electrode mixture.

$$P(\%) = (C1/C2) \times 100$$

(1)

TABLE 2

Material	Air battery			Alkaline dry battery		
	Electrolyte additive		Discharge capacity (mAh)	Discharge capacity (mAh)		
	LiOH (wt %)	Al(OH) ₃ (wt %)	P (%)		P (%)	
A1	0	0	45	855	46	2223
A2	0.01	0.0001	62	865	63	2249
A3	0.05	0.0005	64	875	65	2275
A4	0.08	0.0008	65	899	66	2337
A5	0.1	0.001	91	920	93	2372
A6	0.2	0.005	93	925	95	2405
A7	0.8	0.01	91	922	93	2397
A8	1	0.05	92	919	94	2389
A9	1.3	0.1	89	930	91	2418
A10	1.5	0.15	88	925	90	2405
A11	1.8	0.18	87	915	89	2379
A12	2	0.2	86	908	88	2353
A13	2.5	0.25	66	878	67	2283
A14	3	0.3	62	869	63	2259
B1	0	0	46	860	47	2236
B2	0.01	0.0001	63	870	64	2262
B3	0.05	0.0005	65	880	66	2288
B4	0.08	0.0008	66	904	67	2350
B5	0.1	0.001	92	925	94	2405
B6	0.5	0.005	94	930	96	2418

TABLE 2-continued

Material	Electrolyte additive		Air battery		Alkaline dry battery	
	LiOH (wt %)	Al(OH) ₃ (wt %)	P (%)	capacity (mAh)	P (%)	capacity (mAh)
B7	0.8	0.01	92	927	94	2410
B8	1	0.05	93	924	95	2402
B9	1.3	0.1	90	935	92	2431
B10	1.5	0.15	89	930	91	2418
B11	1.8	0.18	88	920	90	2392
B12	2	0.2	87	910	89	2366
B13	2.5	0.25	67	883	68	2296
B14	3	0.3	63	874	64	2272
C1	0	0	48	865	49	2257
C2	0.01	0.0001	65	878	66	2283
C3	0.05	0.0005	67	888	68	2309
C4	0.08	0.0008	68	912	69	2371
C5	0.1	0.001	94	933	95	2426
C6	0.5	0.005	96	938	97	2439
C7	0.8	0.01	94	935	95	2431
C8	1	0.05	95	932	96	2423
C9	1.3	0.1	92	943	94	2452
C10	1.5	0.15	91	938	93	2439
C11	1.8	0.18	90	928	92	2413
C12	2	0.2	89	918	91	2387
C13	2.5	0.25	69	891	70	2317
C14	3	0.3	65	882	66	2293

[0036] As is clear from Table 2, when LiOH and the aluminum compound are not added to the electrolyte, the P values of the air batteries are as low as 50% or less and the P values (%) of the alkaline dry batteries are also as low as 50% or less, in comparison with those when they are added. Although not shown in Table 2, when the electrolyte contains no aluminum compound and contains only LiOH, the aluminum in the zinc alloy dissolves in the electrolyte, thereby breaking the conductive film comprising Zn, O, and K. Also, when the electrolyte contains no LiOH and contains only the aluminum compound, a passivation film is formed on the zinc alloy surface. For these reasons, the P values (%) of both air batteries and alkaline dry batteries are as low as 50% or less.

[0037] As is clear from the above, in air batteries and alkaline dry batteries including as an active material a zinc alloy that contains at least aluminum, an alkaline electrolyte, and a positive electrode, the addition of LiOH and an aluminum compound to the alkaline electrolyte provides high discharge capacity on a high-rate discharge.

[0038] With respect to the amounts of LiOH and aluminum compound added, when the contents of LiOH and aluminum compound in the negative electrode mixture are lower than 0.1 wt % and 0.001 wt %, respectively, or higher than 2 wt % and 0.2 wt %, respectively, the P values (%) are in the 60% range. However, when the contents of LiOH and aluminum compound are 0.1 to 2 wt % and 0.001 to 0.2 wt %, respectively, the P values (%) are high, specifically 85% or more, which means that the high-rate discharge characteristics are excellent. Further, when the contents of LiOH and aluminum compound are 0.1 to 1 wt % and 0.001 to 0.05 wt %, respectively, the P values are high, specifically 92% or more, which means that the high-rate discharge characteristics are more preferable.

[0039] Note that the LiOH contents of 0.1 to 2 wt % in the negative electrode mixture correspond to 0.1 to 3 parts by weight per 100 parts by weight of the zinc alloy. Also, the aluminum compound contents of 0.001 to 0.2 wt % in the negative electrode mixture correspond to 0.0015 to 0.3 parts by weight per 100 parts by weight of the zinc alloy.

[0040] Also, if the amount of each element of Al, Bi, In, Ca, Sn, and Pb added to the zinc alloy used in the negative electrode is in the range of 20 ppm to 5000 ppm, gas production can be effectively prevented. If it is in the range of 50 ppm to 1000 ppm, gas production can be more effectively prevented.

Example 2

[0041] Next, using the alloy containing Al, Bi, and In in the negative electrode, air batteries and alkaline dry batteries were fabricated in the same manner as the above. Table 3 shows the electrolyte additives and the weight ratios of the electrolyte to the zinc alloy. It should be noted that in Example 1 the weight ratio of the electrolyte to the zinc alloy is 0.5.

[0042] These batteries were placed in a constant temperature oven at 20° C. and a relative humidity of 60%. The air batteries were discharged at a current of 165 mA, and the alkaline dry batteries were discharged at a current of 1050 mA, whereby the discharge capacity C1 was obtained. In the same manner as the above, the theoretical capacity C2 was calculated from the weight of Zn contained in the negative electrode of each battery, and the proportion P (%) of the discharge capacity C1 to the theoretical capacity C2 was calculated. Also, to obtain battery capacity, the air batteries were discharged at a current of 2 mA and the alkaline dry batteries were discharged at a current of 45 mA. Table 3 shows the results.

TABLE 3

Material	Electrolyte additive		Electrolyte/ zinc alloy (weight ratio)	Discharge		Discharge	
	LiOH (wt %)	Al(OH) ₃ (wt %)		P (%)	capacity (mAh)	P (%)	capacity (mAh)
A7	0.21	0.001	0.05	82	921	84	2579
A7	0.21	0.001	0.08	85	923	87	2584
A7	0.21	0.001	0.1	90	925	92	2590
A7	0.21	0.001	0.8	91	925	93	2590
A7	0.21	0.001	1.5	92	920	94	2576
A7	0.21	0.001	2	93	910	95	2548
A7	0.21	0.001	2.5	94	720	96	2016
A7	0.21	0.001	3	94	500	96	1400
B7	0.21	0.001	0.05	83	926	85	2592
B7	0.21	0.001	0.08	86	928	88	2597

TABLE 3-continued

Material	Air battery			Alkaline dry battery		
	Electrolyte additive		Electrolyte/	Discharge	Discharge	
	LiOH (wt %)	Al(OH) ₃ (wt %)	zinc alloy/ weight ratio	P (%)	capacity (mAh)	P (%)
B7	0.21	0.001	0.1	91	930	93
B7	0.21	0.001	0.8	92	930	94
B7	0.21	0.001	1.5	93	925	95
B7	0.21	0.001	2	94	915	96
B7	0.21	0.001	2.5	95	724	97
B7	0.21	0.001	3	95	503	97
C7	0.21	0.001	0.05	85	933	86
C7	0.21	0.001	0.08	88	935	89
C7	0.21	0.001	0.1	93	937	94
C7	0.21	0.001	0.8	94	937	95
C7	0.21	0.001	1.5	95	932	96
C7	0.21	0.001	2	96	922	97
C7	0.21	0.001	2.5	97	729	98
C7	0.21	0.001	3	97	507	98
					1418	

[0043] As is clear from Table 3, when the weight ratio of the whole electrolyte to the zinc alloy is less than 0.1, the P values (%) of the air batteries and the alkaline dry batteries were in the 80% range, and when the weight ratio of the whole electrolyte to the zinc alloy is greater than 2, the discharge capacities of the air batteries and the alkaline dry batteries at the discharge currents of 2 mA and 45 mA, respectively, were not more than 750 mAh and not more than 2100 mAh, respectively.

[0044] This shows that when the weight ratio of the whole electrolyte to the zinc alloy is in the range of 0.1 to 2, the P values (%) of the air batteries and the alkaline dry batteries are good, specifically 90% or higher, and that the discharge capacities of the air batteries and the alkaline dry batteries at the discharge currents of 2 mA and 45 mA, respectively, are good, specifically not less than 900 mAh and not less than 2500 mAh, respectively. Further, when the weight ratio of the whole electrolyte to the zinc alloy is in the range of 0.1 to 0.8, batteries having higher capacity can be obtained.

[0045] Also, if the amount of each element of Al, Bi, In, Ca, Sn, and Pb added to the zinc alloy used in the negative electrode is in the range of 20 ppm to 5000 ppm, gas production can be effectively prevented. If it is in the range of 50 ppm to 1000 ppm, gas production can be more effectively prevented.

INDUSTRIAL APPLICABILITY

[0046] The present invention is applied to alkaline batteries, such as air batteries and alkaline dry batteries, that use an aluminum-containing zinc alloy as a negative electrode active material.

1. An alkaline battery comprising:
a negative electrode including a negative electrode mixture
that contains a zinc alloy as an active material, said zinc
alloy containing at least aluminum;
an alkaline electrolyte; and
a positive electrode,
wherein said alkaline electrolyte comprises an aqueous
KOH solution and LiOH and an aluminum compound
that are dissolved in said aqueous KOH solution.
2. The alkaline battery in accordance with claim 1, wherein
the amounts of the LiOH and the aluminum compound con-
tained in the electrolyte in said negative electrode mixture are
0.1 to 2 wt % and 0.001 to 0.2 wt % of the negative electrode
mixture, respectively.
3. The alkaline battery in accordance with claim 1, wherein
the amounts of the LiOH and the aluminum compound con-
tained in the electrolyte in said negative electrode mixture are
0.15 to 3 parts by weight and 0.0015 to 0.3 parts by weight per
100 parts by weight of said zinc alloy.
4. The alkaline battery in accordance with claim 1 or 2,
wherein the weight ratio of the whole alkaline electrolyte to
the zinc alloy of the negative electrode is 0.1 to 2.

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